LLNL-CONF-418373

PAGs, DRLs, AALs and Other Alphabet Soup MQOs for Laboratory Analyses

C. T. Wong

October 21, 2009

Radiobioassay and Radiochemical Measurements Conference
San Antonio, TX, United States
October 26, 2009 through October 30, 2009

As an Authorized Derivative Classifier, I have reviewed this information and verify that it does not contain classified information

R. E. Hadley

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Carolyn T. Wong

Lawrence Livermore National Laboratory

FRMAC Laboratory Analysis Working Group

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

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MQOs for Laboratory Analyses

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During an incident of national significance involving radioactive materials protective action guides (PAGs) are established to protect workers and the public from harmful exposure levels of radioactive materials. The PAGs are stated in terms of dose and must be converted to measurable quantities in various media (DRLs).

This workshop will present the current PAGs, methods for converting the PAGs to DRLs, and using the Data Quality Objectives process in the Multi-agency Radiological Laboratory Analytical Protocols Manual (MARLAP), derive measurement quality objectives (MQOs) for the laboratories. Examples from the Empire ’09 exercise will be used in this presentation.

PAGs, DRLs, AALs and Other Alphabet Soup MQOs for Laboratory Analyses

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Objectives

- Protective Action Guides
- Converting from the Protective Action Guides to the Derived Response Levels
- Data Quality Objectives
- Measurement Quality Objectives

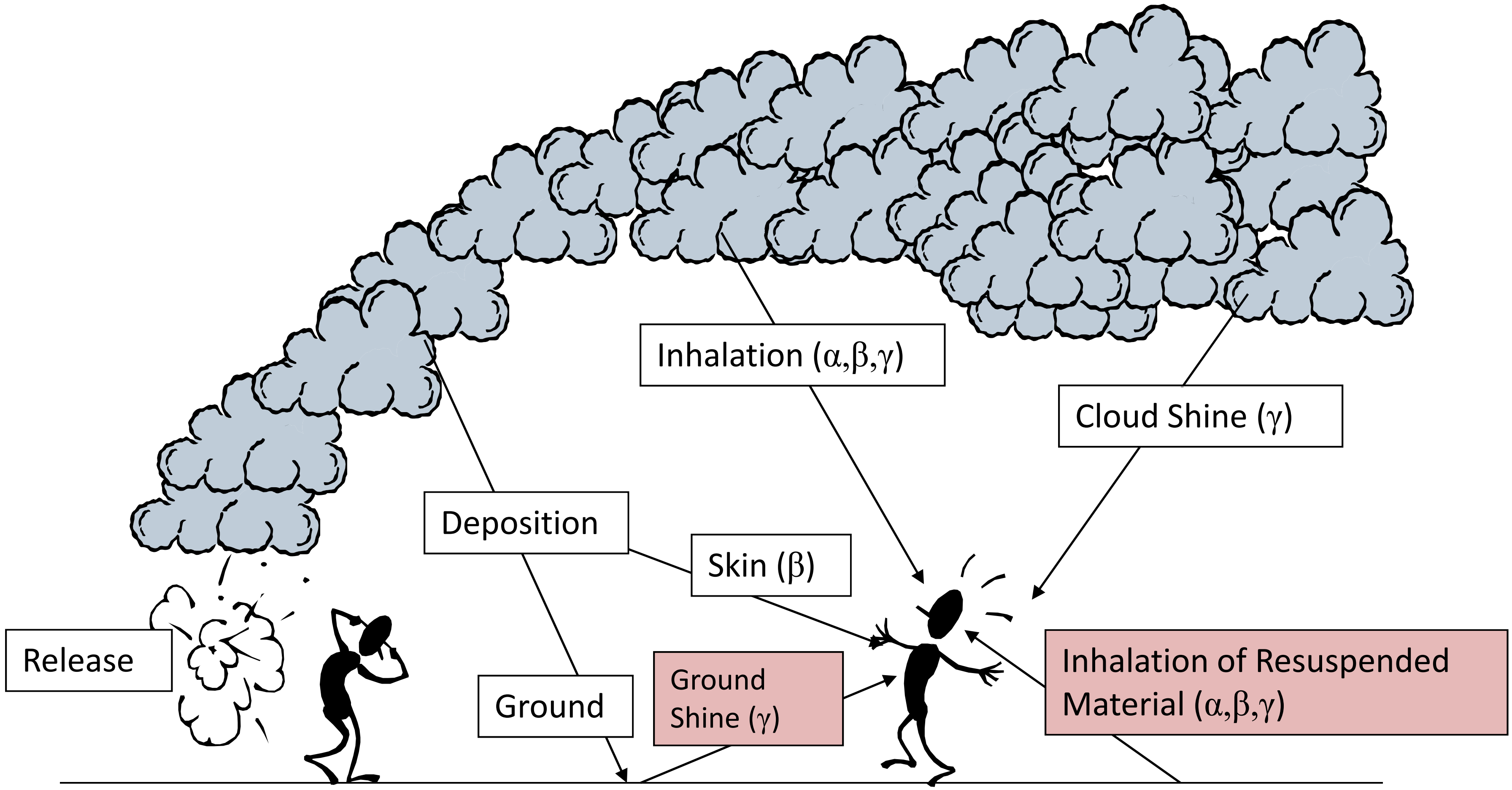
Yes, there will be math!!

Protective Action Guides

PAGS – Protective Action Guides

	Worker	Early Phase	First Year	Second Year	50 Year
Total Effective Dose	1000 mRem	1000 mRem	2000 mRem	500 mRem	5000mRem
Exposure Period	8 hours	4 days (96 hours)	365 days	365 days	50 years

Major Dose Pathways From a Release



(Courtesy of Terry Krause , Sandia National Laboratory)

Derived Response Levels

DRLs – Derived Response Levels

- DRLs are PAGS converted to measurable activity in a sample.
- Assumptions
  - Deposition is evenly distributed
  - Standard re-suspension factor and weathering factors
  - Single radionuclide
  - Radionuclide mixtures

Converting from PAGs to DRLs

$$DRL_{Soil} = \frac{PAG}{DCF_{Soil}}$$

$$DRL_{Air} = \frac{PAG}{(DCF_{Air})(Exposure\,Time)}$$

$$DRL_{Air} = (DRL_{Soil})(Re-suspension\ Factor)$$

$$DRL_{Water} = \frac{PAG}{(DCF_{Water})(Intake\,Rate)(Exposure\,Period)}$$

DCF – Dose Conversion Factor

- Dose rate from a radionuclide per unit activity.

$$DCF_{Soil} = \frac{mRem}{\mu Ci/m^2} \qquad DCF_{Air} = \frac{mRem/hr}{\mu Ci/m^3} \qquad DCF_{Water} = \frac{mRem}{\mu Ci}$$

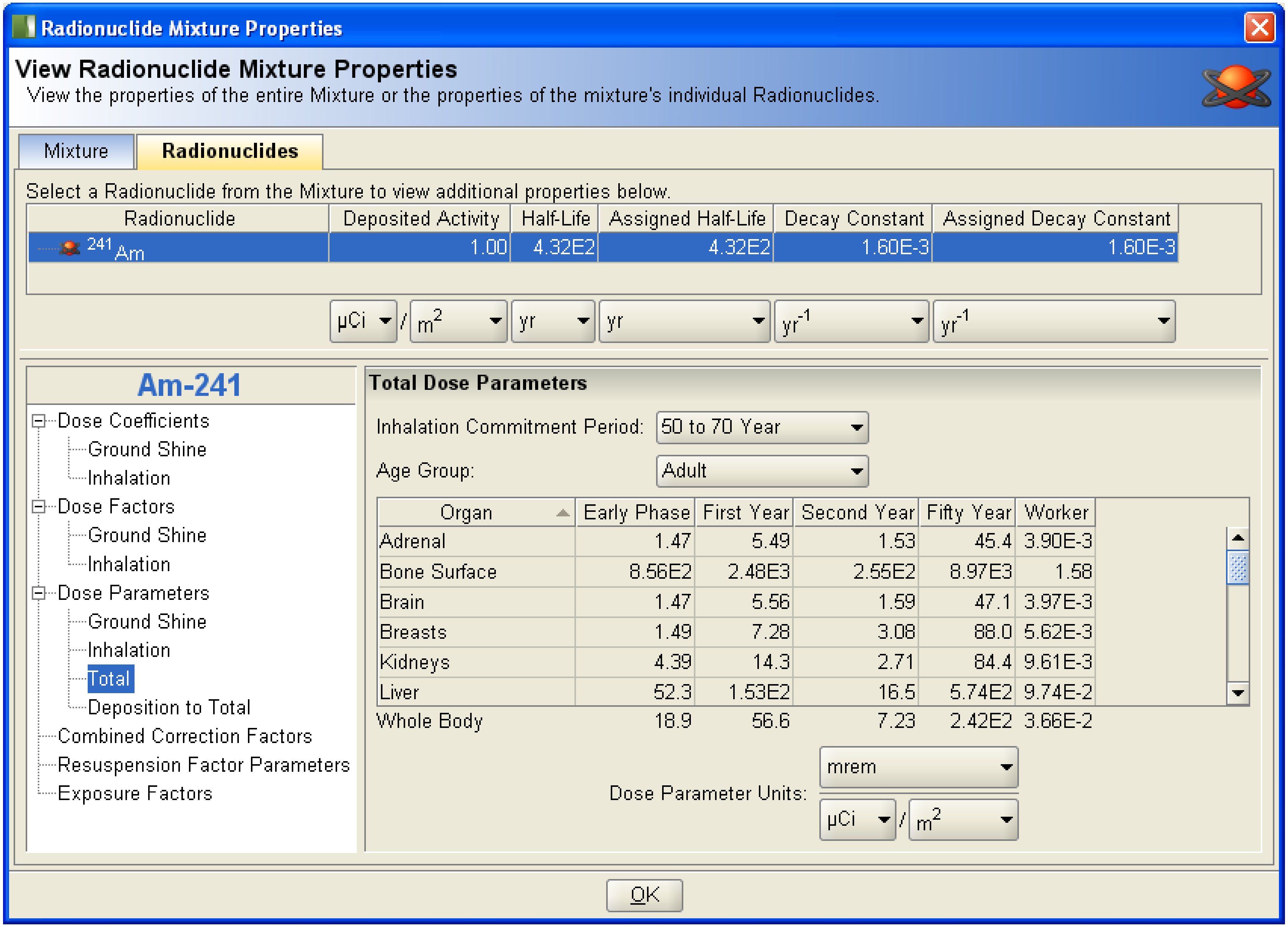
  - The soil DCF incorporates both the Inhalation Dose (based on the re-suspension factor and the breathing rate) and the External Dose (incorporating a weathering factor, radioactive decay, and a ground roughness factor).
  - The exposure rate (mRem/hr) and the exposure time (hr) are incorporated into the soil DCF.

  - The air DCF is for the Inhalation Dose only.
  - The rate of dose accumulation (breathing rate) is incorporated into the air DCF.

Where to Find the DCFs

- FRMAC Laboratory Assessment Manual - Tables, Charts, Worksheets, Glossary, Volume2
- ICRP 60 plus dosimetry models, DCFPAK
- Turbo FRMAC

DCFs for Am-241



Radionuclide Mixture Properties

View Radionuclide Mixture Properties

View the properties of the entire Mixture or the properties of the mixture's individual Radionuclides.

Mixture | **Radionuclides**

Select a Radionuclide from the Mixture to view additional properties below.

Radionuclide	Deposited Activity	Half-Life	Assigned Half-Life	Decay Constant	Assigned Decay Constant
^{241}Am	1.00	4.32E2	4.32E2	1.60E-3	1.60E-3
	µCi / m^2	yr	yr	yr^{-1}	yr^{-1}

Am-241

- Dose Coefficients
  - Ground Shine
  - Inhalation
- Dose Factors
  - Ground Shine
  - Inhalation
- Dose Parameters
  - Ground Shine
  - Inhalation
  - Total
  - Deposition to Total
- Combined Correction Factors
- Resuspension Factor Parameters
- Exposure Factors

Total Dose Parameters

Inhalation Commitment Period: 50 to 70 Year

Age Group: Adult

Organ	Early Phase	First Year	Second Year	Fifty Year	Worker
Adrenal	1.47	5.49	1.53	45.4	3.90E-3
Bone Surface	8.56E2	2.48E3	2.55E2	8.97E3	1.58
Brain	1.47	5.56	1.59	47.1	3.97E-3
Breasts	1.49	7.28	3.08	88.0	5.62E-3
Kidneys	4.39	14.3	2.71	84.4	9.61E-3
Liver	52.3	1.53E2	16.5	5.74E2	9.74E-2
Whole Body	18.9	56.6	7.23	2.42E2	3.66E-2

Dose Parameter Units: mrem / µCi / m^2

OK

DRLs for Soil

Example: Am-241 in Soil, Early Phase

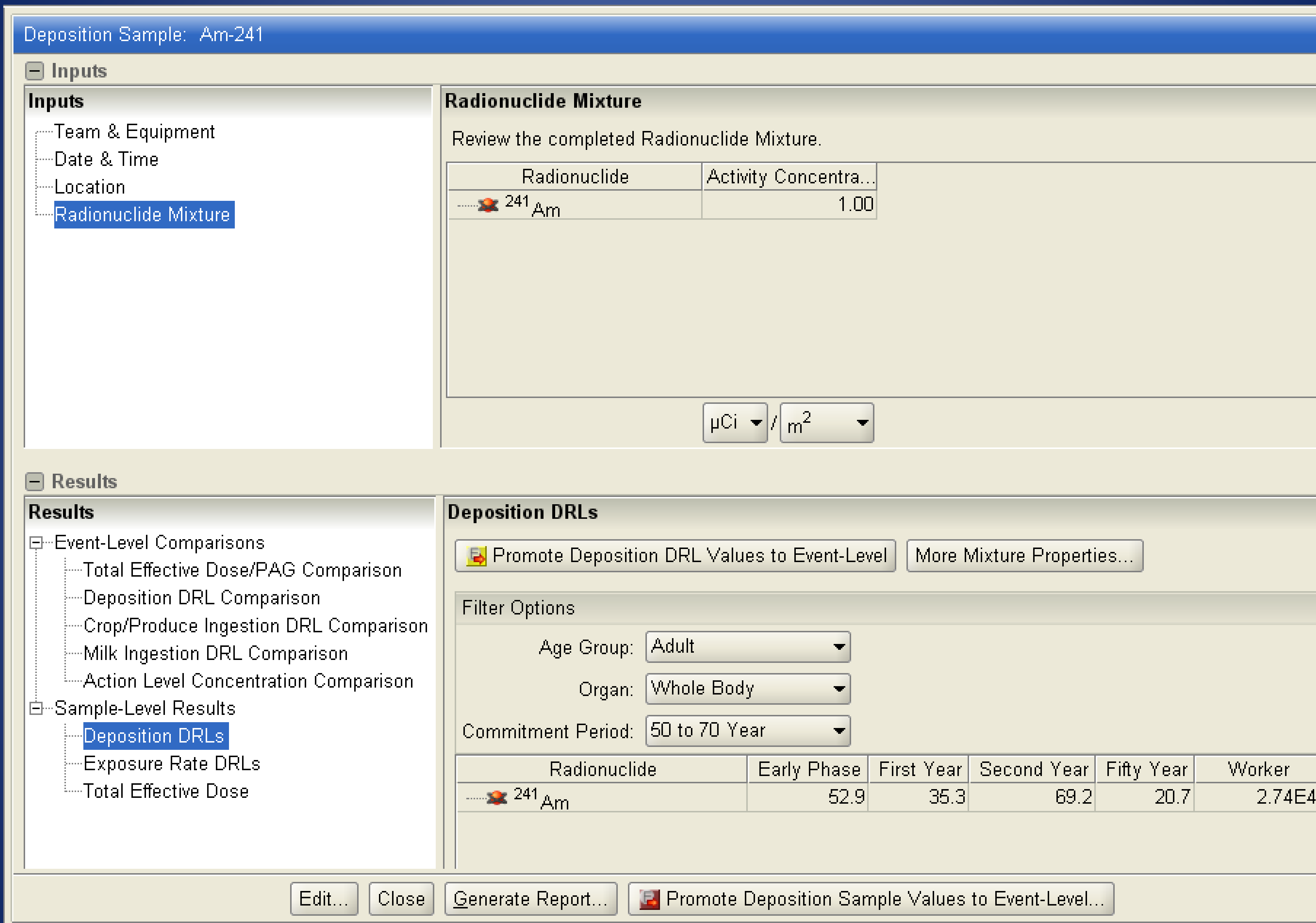
- PAG: 1000 mRem over 96 hours
- DCF_{Soil}: 1.89E+01 mRem/(μCi/m^2)
- Sample size: 100 cm^2 x 2 cm deep (200 cm^3)
- Soil density: 1.75 g/cm^3 (350 g/sample)

Example: Am-241 in Soil, Early Phase

$$DRL_{Soil} = \frac{1000\,mRem}{\left(1.89\text{E}+01\,\frac{mRem}{\mu Ci/m^2}\right)} = 5.29\text{E}+01\ \mu Ci/m^2$$

$$\left(5.29\text{E}+01\ \mu Ci/m^2\right)\left(\frac{100\,cm^2}{Sample}\right)\left(\frac{1\,m^2}{100\ cm^2}\right) = 5.29\text{E}-01\ \mu Ci/Sample$$

$$\frac{\left(5.29\text{E}-01\ \mu Ci/Sample\right)}{\left(350\ g/Sample\right)}\left(\frac{10^6\ pCi}{\mu Ci}\right) = 1.51\text{E}+03\ pCi/g$$


Deposition Sample: Am-241
Inputs
Inputs
Team & Equipment
Date & Time
Location
Radionuclide Mixture
Radionuclide Mixture
Review the completed Radionuclide Mixture.
Radionuclide
Activity Concentra...
241 Am
1.00
µCi / m2
Results
Results
Event-Level Comparisons
Total Effective Dose/PAG Comparison
Deposition DRL Comparison
Crop/Produce Ingestion DRL Comparison
Milk Ingestion DRL Comparison
Action Level Concentration Comparison
Sample-Level Results
Deposition DRLs
Exposure Rate DRLs
Total Effective Dose
Deposition DRLs
Promote Deposition DRL Values to Event-Level
More Mixture Properties...
Filter Options
Age Group: Adult
Organ: Whole Body
Commitment Period: 50 to 70 Year
Radionuclide
Early Phase
First Year
Second Year
Fifty Year
Worker
241 Am
52.9
35.3
69.2
20.7
2.74E4
Edit...
Close
Generate Report...
Promote Deposition Sample Values to Event-Level...

Early Phase DRLs - Soil

Radionuclide	μCi/m²	μCi/Sample[1]	pCi/g
Am-241	5.29E+01	5.29E-01	1.51E+03
Po-210	1.21E+03	1.21E+01	3.45E+04
Pu-239	4.29E+01	4.29E-01	1.23E+03
U-238	6.33E+02	6.33E+00	1.81E+04
Co-60	4.15E+02	4.15E+00	1.19E+04
Cs-137[2]	9.26E+04	9.26E+02	2.65E+06
Ir-192	1.25E+03	1.25E+01	3.57E+04
Sr-90[2]	3.08E+04	3.08E+02	8.89E+05

1. 100 cm² x 2 cm deep (350 g)
2. Decay products are not included

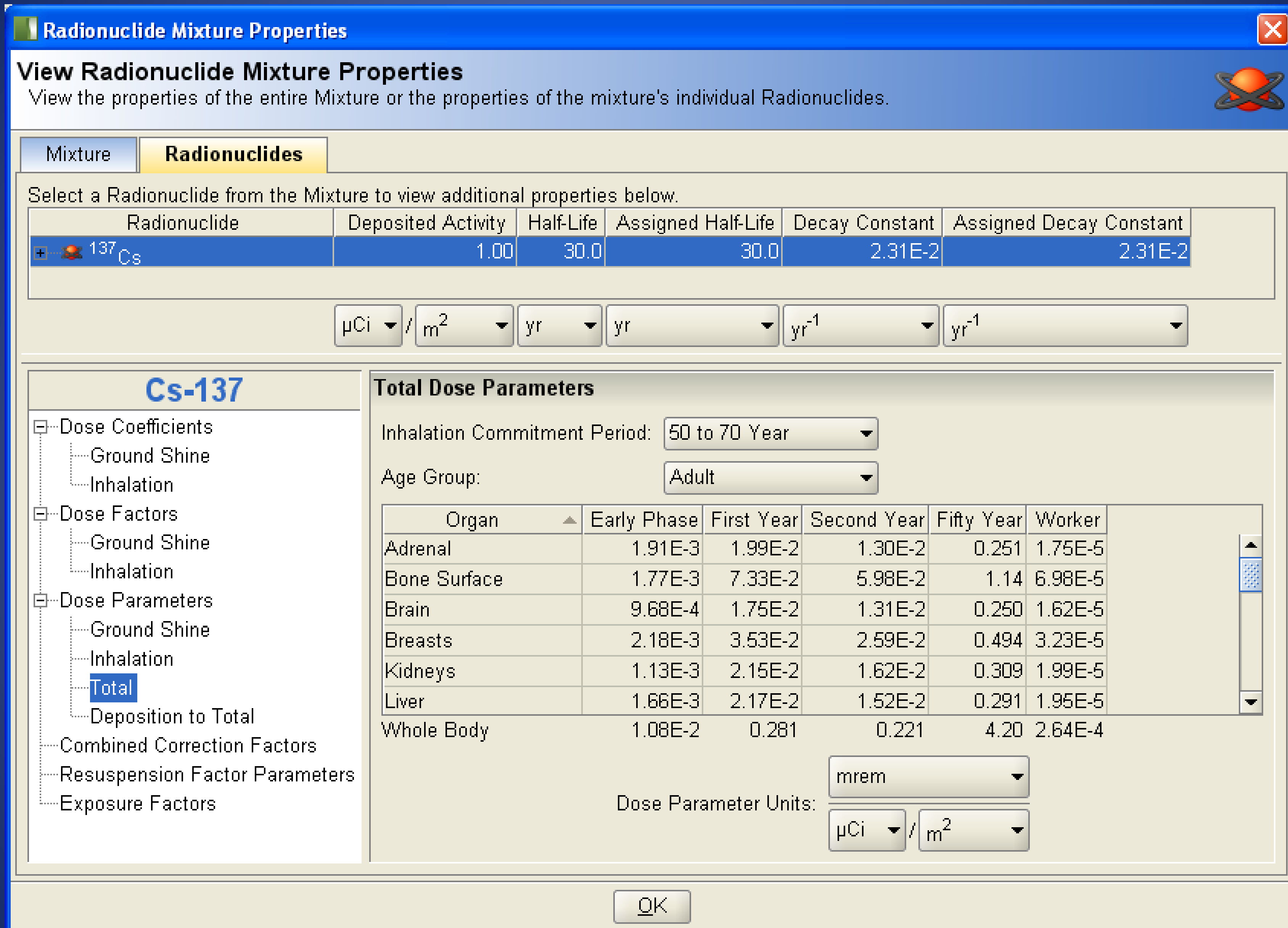
DRLs are Scalable

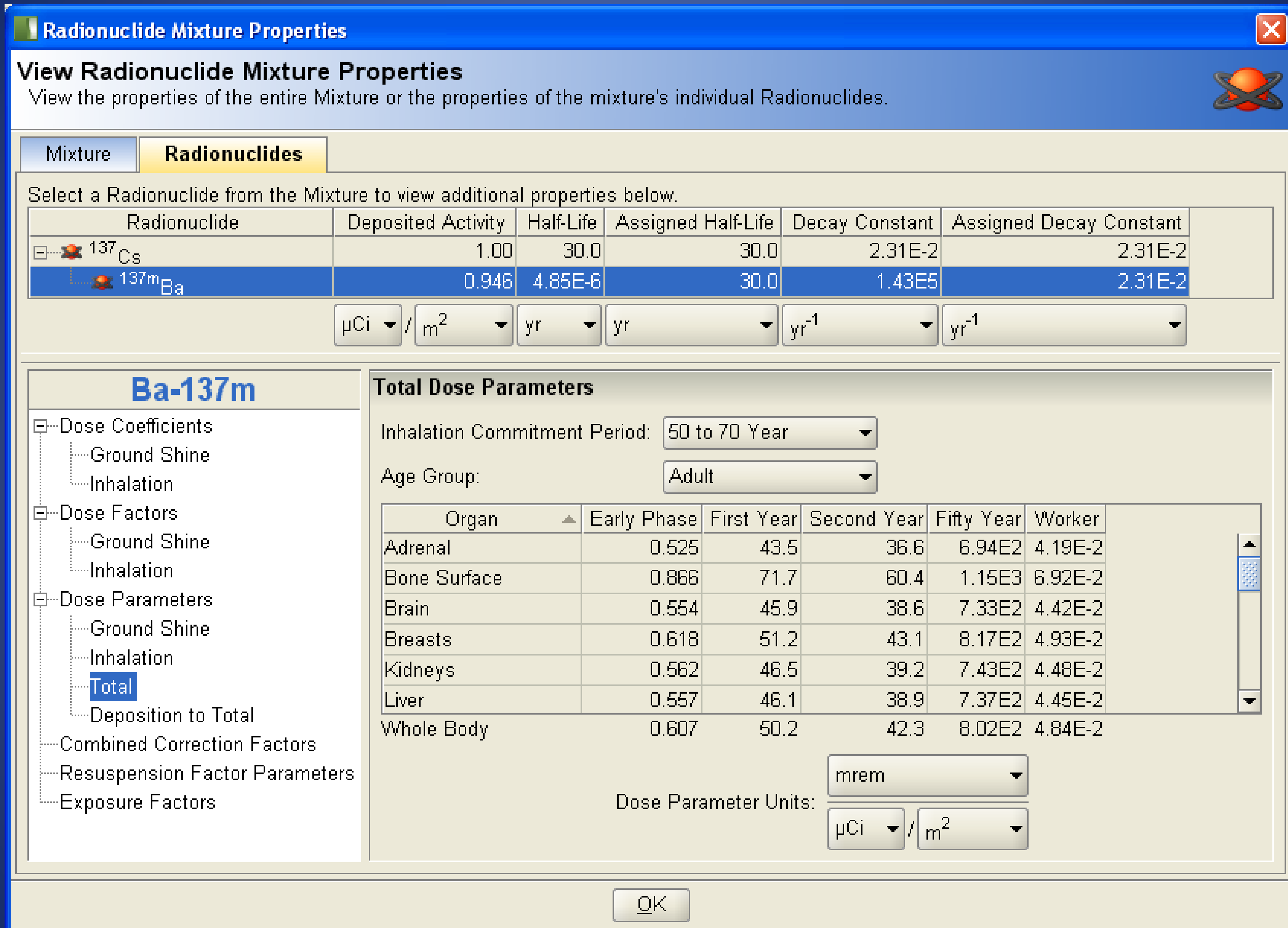
- What if Incident Command decides to set the Early Phase PAG at 500 mRem?

$$(5.29\text{E}-01\ \mu Ci/Sample)\left(\frac{500\ mRem}{1000\ mRem}\right) = 2.65\text{E-}01\ \mu Ci/Sample$$

  - Since the soil DCF incorporates the exposure time, one needs to derive new DRLs if the PAGS refer to different time periods *(e.g.* Worker Dose is calculated over 8 hours instead of 96 hours for the Early Phase PAG).

Decay Products


Radionuclide Mixture Properties
View Radionuclide Mixture Properties
View the properties of the entire Mixture or the properties of the mixture's individual Radionuclides.
Mixture
Radionuclides
Select a Radionuclide from the Mixture to view additional properties below.
Radionuclide | Deposited Activity | Half-Life | Assigned Half-Life | Decay Constant | Assigned Decay Constant
137Cs | 1.00 | 30.0 | 30.0 | 2.31E-2 | 2.31E-2
µCi / m2 | yr | yr | yr-1 | yr-1
Cs-137
Dose Coefficients
Ground Shine
Inhalation
Dose Factors
Ground Shine
Inhalation
Dose Parameters
Ground Shine
Inhalation
Total
Deposition to Total
Combined Correction Factors
Resuspension Factor Parameters
Exposure Factors
Total Dose Parameters
Inhalation Commitment Period: 50 to 70 Year
Age Group: Adult
Organ | Early Phase | First Year | Second Year | Fifty Year | Worker
Adrenal | 1.91E-3 | 1.99E-2 | 1.30E-2 | 0.251 | 1.75E-5
Bone Surface | 1.77E-3 | 7.33E-2 | 5.98E-2 | 1.14 | 6.98E-5
Brain | 9.68E-4 | 1.75E-2 | 1.31E-2 | 0.250 | 1.62E-5
Breasts | 2.18E-3 | 3.53E-2 | 2.59E-2 | 0.494 | 3.23E-5
Kidneys | 1.13E-3 | 2.15E-2 | 1.62E-2 | 0.309 | 1.99E-5
Liver | 1.66E-3 | 2.17E-2 | 1.52E-2 | 0.291 | 1.95E-5
Whole Body | 1.08E-2 | 0.281 | 0.221 | 4.20 | 2.64E-4
Dose Parameter Units: mrem / µCi / m2
OK


Radionuclide Mixture Properties
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View the properties of the entire Mixture or the properties of the mixture's individual Radionuclides.
Mixture
Radionuclides
Select a Radionuclide from the Mixture to view additional properties below.
Radionuclide | Deposited Activity | Half-Life | Assigned Half-Life | Decay Constant | Assigned Decay Constant
137Cs | 1.00 | 30.0 | 30.0 | 2.31E-2 | 2.31E-2
137mBa | 0.946 | 4.85E-6 | 30.0 | 1.43E5 | 2.31E-2
µCi / m2 | yr | yr | yr-1 | yr-1
Ba-137m
Dose Coefficients
Ground Shine
Inhalation
Dose Factors
Ground Shine
Inhalation
Dose Parameters
Ground Shine
Inhalation
Total
Deposition to Total
Combined Correction Factors
Resuspension Factor Parameters
Exposure Factors
Total Dose Parameters
Inhalation Commitment Period: 50 to 70 Year
Age Group: Adult
Organ | Early Phase | First Year | Second Year | Fifty Year | Worker
Adrenal | 0.525 | 43.5 | 36.6 | 6.94E2 | 4.19E-2
Bone Surface | 0.866 | 71.7 | 60.4 | 1.15E3 | 6.92E-2
Brain | 0.554 | 45.9 | 38.6 | 7.33E2 | 4.42E-2
Breasts | 0.618 | 51.2 | 43.1 | 8.17E2 | 4.93E-2
Kidneys | 0.562 | 46.5 | 39.2 | 7.43E2 | 4.48E-2
Liver | 0.557 | 46.1 | 38.9 | 7.37E2 | 4.45E-2
Whole Body | 0.607 | 50.2 | 42.3 | 8.02E2 | 4.84E-2
Dose Parameter Units: mrem
µCi / m2
OK

Radionuclide Mixture Properties

View Radionuclide Mixture Properties

View the properties of the entire Mixture or the properties of the mixture's individual Radionuclides.

Mixture | Radionuclides

Mixture Properties

- Deposition External Exposure Factor
- Deposition Total Dose Parameters
- External Exposure to Total Dose Parameters

Deposition Total Dose Parameters

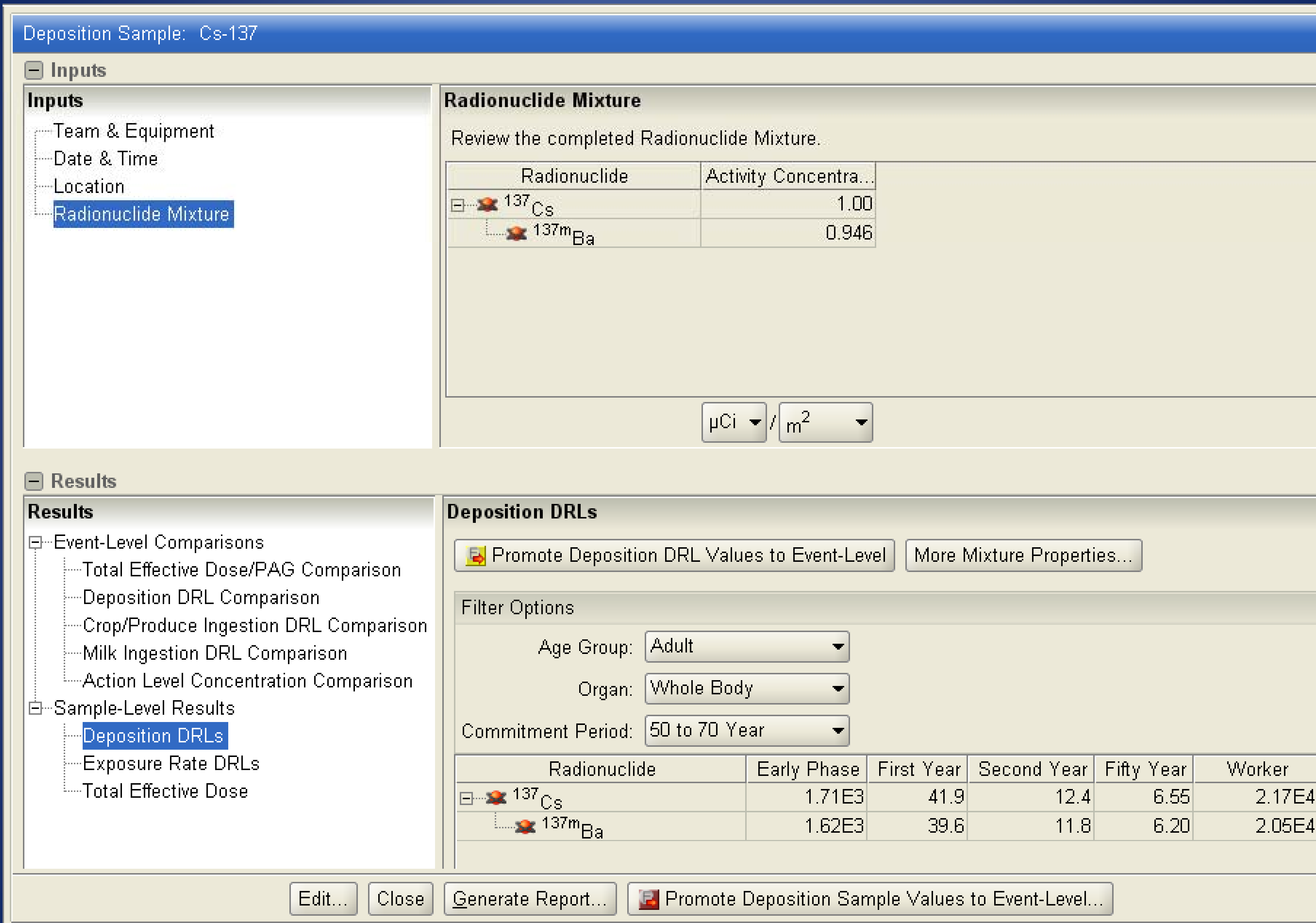
Commitment Period: 50 to 70 Year

Age Group: Adult

Organ	Early Phase	First Year	Second Year	Fifty Year	Worker
Adrenal	0.498	41.1	34.6	6.57E2	3.97E-2
Bone Surface	0.821	67.9	57.2	1.09E3	6.55E-2
Brain	0.525	43.4	36.6	6.94E2	4.19E-2
Breasts	0.587	48.4	40.8	7.74E2	4.67E-2
Kidneys	0.532	44.0	37.1	7.03E2	4.24E-2
Liver	0.529	43.7	36.8	6.98E2	4.21E-2
Lower Large Intestine	0.536	44.3	37.3	7.08E2	4.27E-2
Lung	0.614	46.2	38.8	7.36E2	4.45E-2
Muscle	0.604	49.9	42.0	7.97E2	4.81E-2
Ovaries	0.536	44.3	37.3	7.08E2	4.27E-2
Pancreas	0.486	40.1	33.8	6.41E2	3.87E-2
Red Marrow	0.566	46.8	39.4	7.47E2	4.51E-2
Skin	1.92	1.59E2	1.34E2	2.54E3	0.154
Small Intestine	0.515	42.6	35.9	6.80E2	4.11E-2
Whole Body	0.585	47.8	40.2	7.63E2	4.61E-2

Total Dose Parameter Units: mrem

OK


Deposition Sample: Cs-137
Inputs
Inputs
Team & Equipment
Date & Time
Location
Radionuclide Mixture
Radionuclide Mixture
Review the completed Radionuclide Mixture.
Radionuclide | Activity Concentra...
137Cs | 1.00
137mBa | 0.946
µCi / m2
Results
Results
Event-Level Comparisons
Total Effective Dose/PAG Comparison
Deposition DRL Comparison
Crop/Produce Ingestion DRL Comparison
Milk Ingestion DRL Comparison
Action Level Concentration Comparison
Sample-Level Results
Deposition DRLs
Exposure Rate DRLs
Total Effective Dose
Deposition DRLs
Promote Deposition DRL Values to Event-Level
More Mixture Properties...
Filter Options
Age Group: Adult
Organ: Whole Body
Commitment Period: 50 to 70 Year
Radionuclide | Early Phase | First Year | Second Year | Fifty Year | Worker
137Cs | 1.71E3 | 41.9 | 12.4 | 6.55 | 2.17E4
137mBa | 1.62E3 | 39.6 | 11.8 | 6.20 | 2.05E4
Edit...
Close
Generate Report...
Promote Deposition Sample Values to Event-Level...

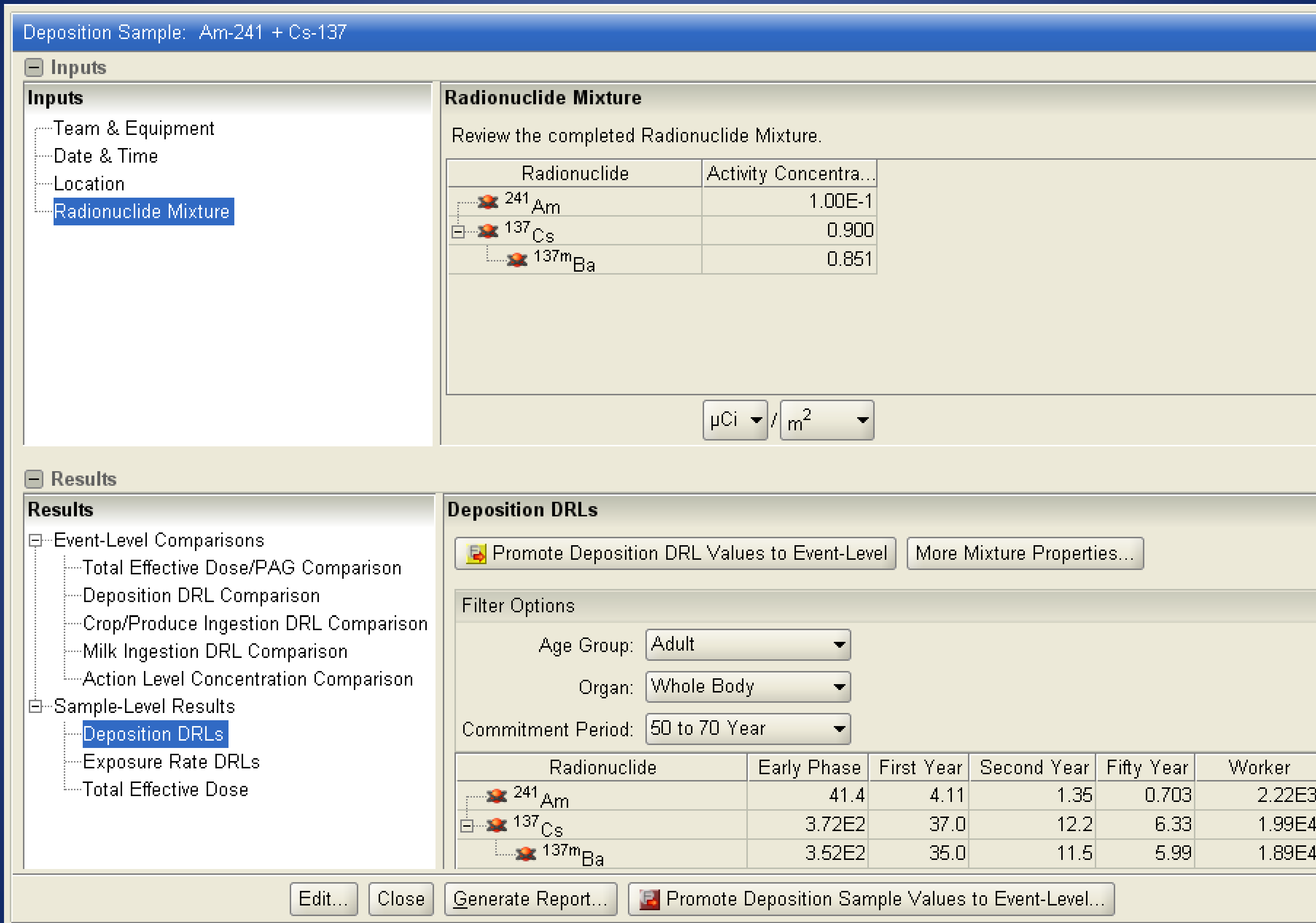
Early Phase DRLs - Soil

Radionuclide	μCi/m²	μCi/Sample[1]	pCi/g
Am-241	5.29E+01	5.29E-01	1.51E+03
Po-210	1.21E+03	1.21E+01	3.45E+04
Pu-239	4.29E+01	4.29E-01	1.23E+03
U-238	6.33E+02	6.33E+00	1.81E+04
Co-60	4.15E+02	4.15E+00	1.19E+04
Cs-137/Ba-137m	**1.71E+03**	**1.71E+01**	**4.89e+04**
Ir-192	1.25E+03	1.25E+01	3.57E+04
Sr-90/Y-90	**6.76E+03**	**6.76E+01**	**1.93E+05**

1. 100 cm^2 x 2 cm deep (350 g)

Mixtures of Radionuclides

- Am-241 = 10% of total activity
- Cs-137 = 90% of total activity


Deposition Sample: Am-241 + Cs-137
Inputs
Inputs
Team & Equipment
Date & Time
Location
Radionuclide Mixture
Radionuclide Mixture
Review the completed Radionuclide Mixture.
Radionuclide
Activity Concentra...
241Am 1.00E-1
137Cs 0.900
137mBa 0.851
µCi / m2
Results
Results
Event-Level Comparisons
Total Effective Dose/PAG Comparison
Deposition DRL Comparison
Crop/Produce Ingestion DRL Comparison
Milk Ingestion DRL Comparison
Action Level Concentration Comparison
Sample-Level Results
Deposition DRLs
Exposure Rate DRLs
Total Effective Dose
Deposition DRLs
Promote Deposition DRL Values to Event-Level
More Mixture Properties...
Filter Options
Age Group: Adult
Organ: Whole Body
Commitment Period: 50 to 70 Year
Radionuclide | Early Phase | First Year | Second Year | Fifty Year | Worker
241Am | 41.4 | 4.11 | 1.35 | 0.703 | 2.22E3
137Cs | 3.72E2 | 37.0 | 12.2 | 6.33 | 1.99E4
137mBa | 3.52E2 | 35.0 | 11.5 | 5.99 | 1.89E4
Edit...
Close
Generate Report...
Promote Deposition Sample Values to Event-Level...

DRLs for Air

DRLS for Air Filter Samples

- What question are we trying to answer?
- Individual standing in the middle of a plume during plume passage?

(Internal Dose only, no ground shine, no cloud shine)

$$DRL_{Air} = \frac{PAG}{(DCF_{Air})(Exposure\,Time)}$$

DRLS for Air Filter Samples

- Individual standing in the air contaminated by re-suspension from the soil?

  (Internal Dose plus External Dose)

$$DRL_{Air} = (DRL_{Soil})(Re - suspension\ Factor)$$

- Confirmation of ground deposition results?
- Confirmation of re-suspension factor?

$$Re - suspension\ Factor = \frac{Activity_{Air}(\mu Ci / m^3)}{Activity_{Soil}(\mu Ci / m^2)}$$

  – Re-suspension Factor = 1E-06 m^{-1}

Example: Am-241 in Air, Worker Dose

- PAG: 1000 mRem over 8 hours
- DRL_{Soil}: 3.79E+02 μCi/m^2
- Sample size: 40 ft^3/min. for 10 min (400 ft^3, 11.2 m^3,~10 m^3)

$$DRL_{Air} = \left(3.79E+02\ \mu Ci/m^2\right)\left(1E-06\ m^{-1}\right)$$
$$= 3.79E-04\ \mu Ci/m^3$$

$$\left(3.79\mathrm{E}-04\ \mu Ci/m^3\right)\left(10\ m^3\right) = 3.79\mathrm{E}-03\ \mu Ci/Sample$$
$$= 3.79\mathrm{E}+03\ pCi/Sample$$

Worker Dose DRLs - Air

Radionuclide	$\mu Ci/m^3$	μCi/Sample[1]	pCi/Sample[1]
Am-241	3.79E-04	3.79E-03	3.79E+03
Po-210	8.62E-03	8.62E-02	8.62E+04
Pu-239	3.07E-04	3.07E-03	3.07E+03
U-238	4.55E-03	4.55E-02	4.55E+04
Co-60	4.95E-03	4.95E-02	4.95E+02
Cs-137/Ba-137m	2.03E-02	2.03E-01	2.03E+05
Ir-192	1.47E-02	1.47E-01	1.47E+05
Sr-90/Y-90	7.10E-02	7.10E-01	7.10E+05

1. 10,000 L /Sample (10 m^3/Sample)

Early Phase DRLs - Air

Radionuclide	$\mu Ci/m^3$	μCi/Sample[1]	pCi/Sample[1]
Am-241	5.29E-05	5.29E-04	5.29E+02
Po-210	1.21E-03	1.21E-02	1.21E+04
Pu-239	4.29E-05	4.29E-04	4.29E+02
U-238	6.33E-04	6.33E-03	6.33E+04
Co-60	4.14E-04	4.14E-03	4.14E+03
Cs-137/Ba-137m	1.71E-03	1.71E-02	1.71E+04
Ir-192	1.25E-03	1.25E-02	1.25E+04
Sr-90/Y-90	6.76E-03	6.76E-02	6.76E+04

1. 10,000 L /Sample (10 m^3/Sample)

DRLs for Water

Water

- EPA DWC – Derived Water Concentration
- Radiological Laboratory Sample Analysis Guide for Incidents of National Significance – Radionuclides in Water, January 2008
- Turbo FRMAC
- Drinking Water Regulations

Different Assumptions for Water

	Age Group	Intake Rate
EPA Guidance[1]	5-year old child	50th percentile (0.66 L/day)
Turbo FRMAC	Adult	2 L/day

1. Dose Conversion Factors in Federal Guidance Report No. 13

Example: Am-241 in Water, Second Year

- EPA Guidance Document
  - 5-year old child
  - 50 percentile Intake Rate: 0.66 L/day
  - DCF_{Water}: 1.01E+03 mRem/µCi

$$DRL_{Water} = \frac{500\ mRem}{\left(1.01\mathrm{E}+03\ \frac{mRem}{\mu Ci}\right)(0.66\ L/day)(365\ days)}$$

$$= 2.06E-03\ \mu Ci/L$$

$$= 2.06\mathrm{E}+03\ pCi/L$$

Example: Am-241 in Water, Second Year

- Turbo FRMAC
  - Adult
  - Intake Rate: 2 L/day
  - DCF_{Water}: 7.55E+02 mRem/μCi

$$DRL_{Water} = \frac{500\ mRem}{\left(7.55\text{E}+02\ \frac{mRem}{\mu Ci}\right)(2\ L/day)(365\ days)}$$

$$= 9.07\text{E}-04\ \mu Ci/L$$

$$= 9.07\text{E}+02\ pCi/L$$

Second Year DRLs - Water

	Turbo FRMAC[1]		EPA Guidance[2]
Radionuclide	μCi/L	pCi/L	pCi/L
Am-241	9.07E-04	9.07E+02	2.0E+03
Po-210	1.53E-04	1.53E+02	1.3E+02
Pu-239	7.37E-04	7.37E+02	1.7E+03
U-238	4.15E-03	4.15E+03	7.0E+03
Co-60	5.39E-02	5.39E+04	3.3E+04
Cs-137[3]	1.36E-02	1.36E+04	5.8E+04
Ir-192	1.35E-01	1.35E+05	1.2E+05
Sr-90[3]	6.65E-03	6.65E+03	1.2E+04

1. Adult, 2 L/Day
2. 5-year old child, 0.66 L/Day
3. DRLs do not include decay products

Other DRLs

Food / Milk / Crops

- FDA DILS – Derived Ingestion Limits
- Activity in crops may also be used to determine ground deposition

Data Quality Objectives

The DQO Process

- Step One: State the Problem
  - Does the radiation present in the environment require the population to be evacuated?
- Step Two: Identify the Decision
  - If the radiation dose rate exceeds the Early Phase PAG, then the population will be evacuated.
  - If the radiation dose rate does not exceed the Early Phase PAG, then no action will be taken.

The DQO Process – Continued

- Step Three: Identify the Inputs to the Problem
  - Results from the sample analyses will be used to determine if the PAG is exceeded.
  - The PAG in terms of measurable activity in a sample is the DRL.
  - The Analytical Action Limit (AAL) is set at the DRL.
  - Results for individual samples will be compared to the AAL to determine if the PAG is exceeded.

    (This is not the same as determining if the PAG is exceeded based on the analysis of n samples from an area.)

The DQO Process – Continued

- Step Four: Define the Study Boundaries
  - Samples will be collected in the areas of the suspected "edges" of the plume.
- Step Five: Develop a Decision Rule
  - If the activity of the analyte in the sample of the area is greater than the AAL, then
  - evacuate the residents, otherwise
  - leave the residents in place.

The DQO Process – Continued

- Step Six: Specify the Limits on Decision Errors
  - The Null Hypothesis:

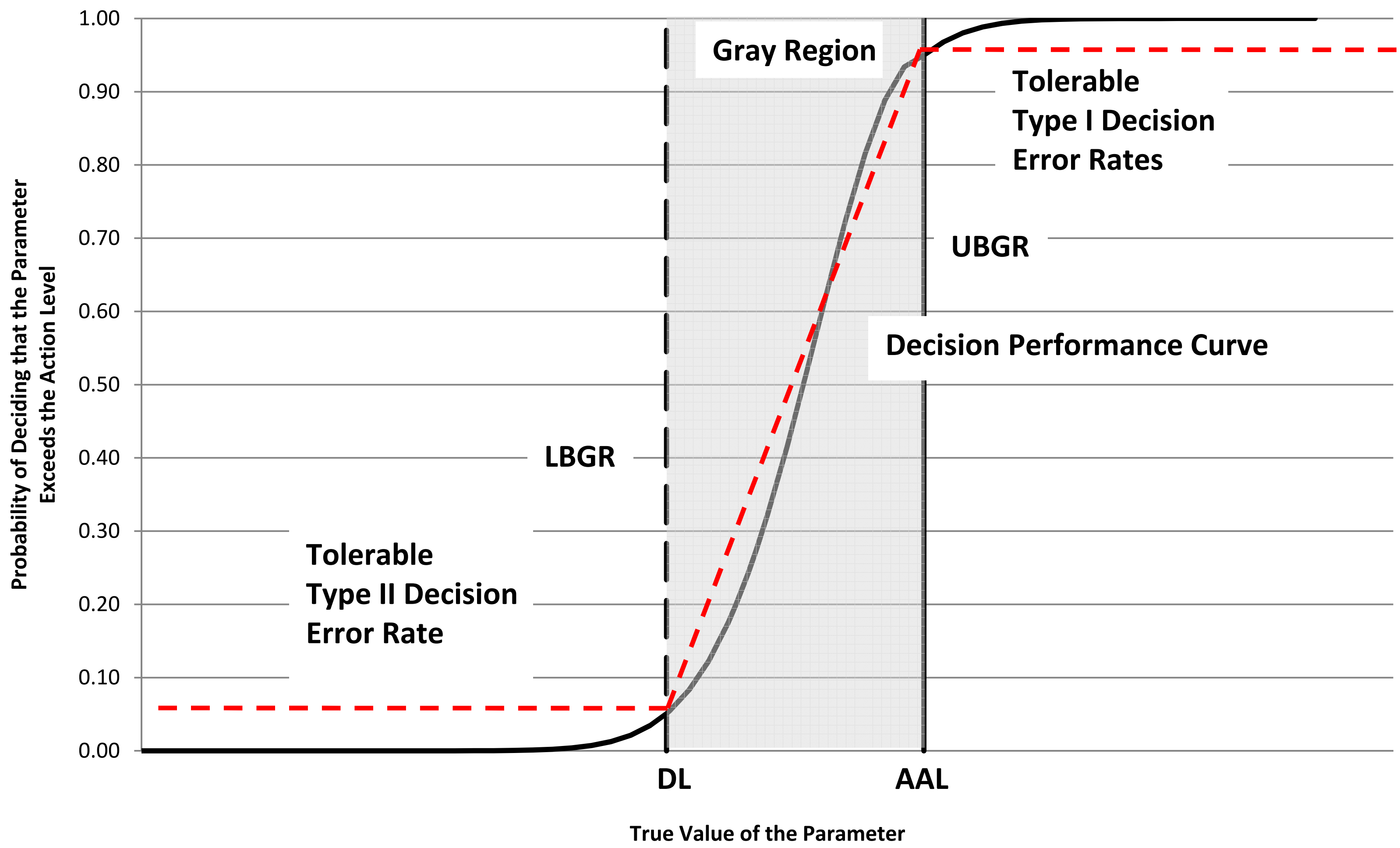
"The activity of the analyte in the sample exceeds the AAL."

  - The Alternative Hypothesis:

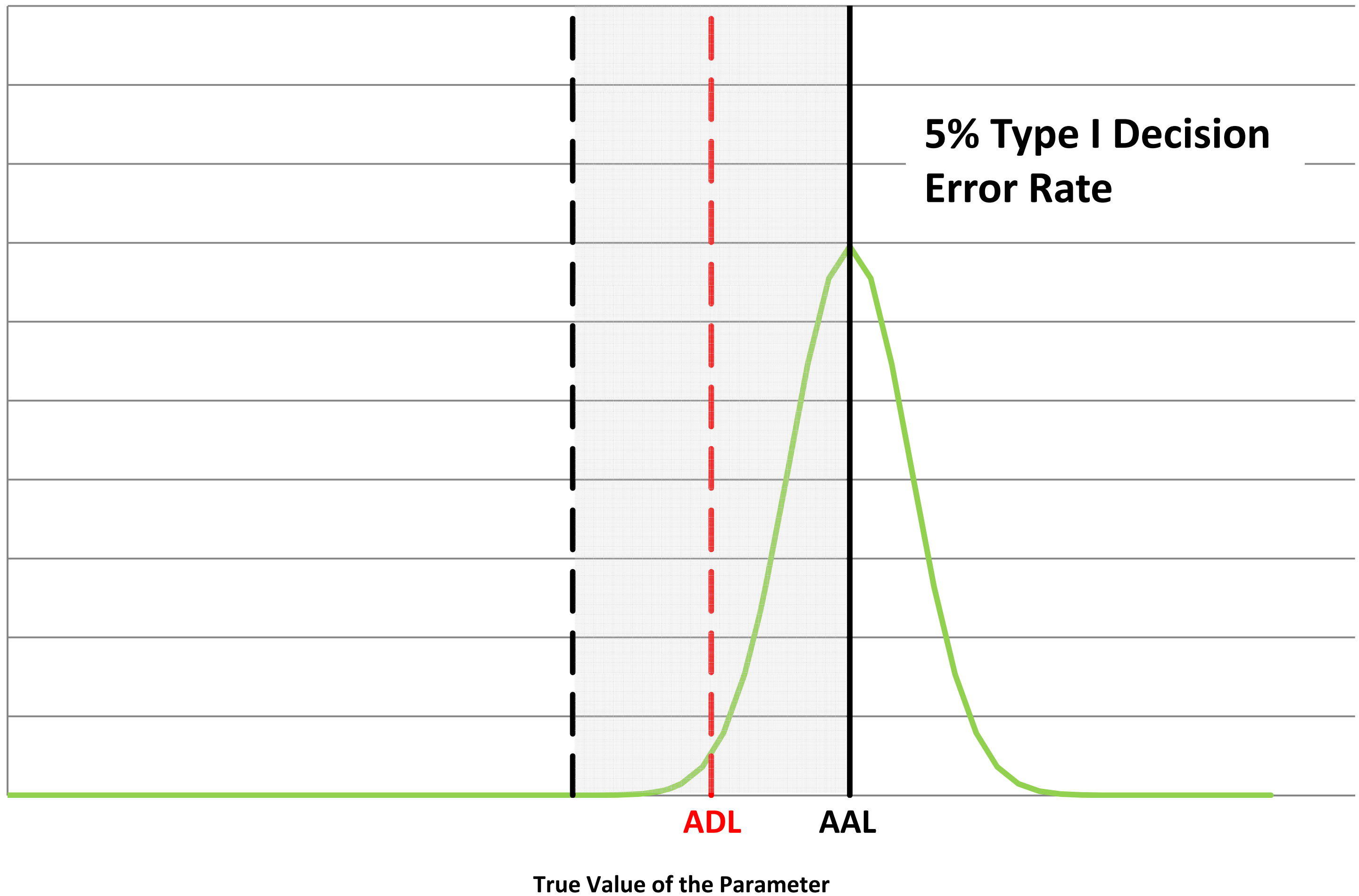
"The activity of the analyte in the sample does not exceed the AAL."

Decision	True State	Error Type	Probability
Deciding the activity of the analyte is below the AAL…	when it actually is above the AAL.	Type I Error (False Negative)	α=5%
Deciding the activity of the analyte in above the AAL…	when it actually is below the AAL.	Type II Error (False Positive)	β = 5%

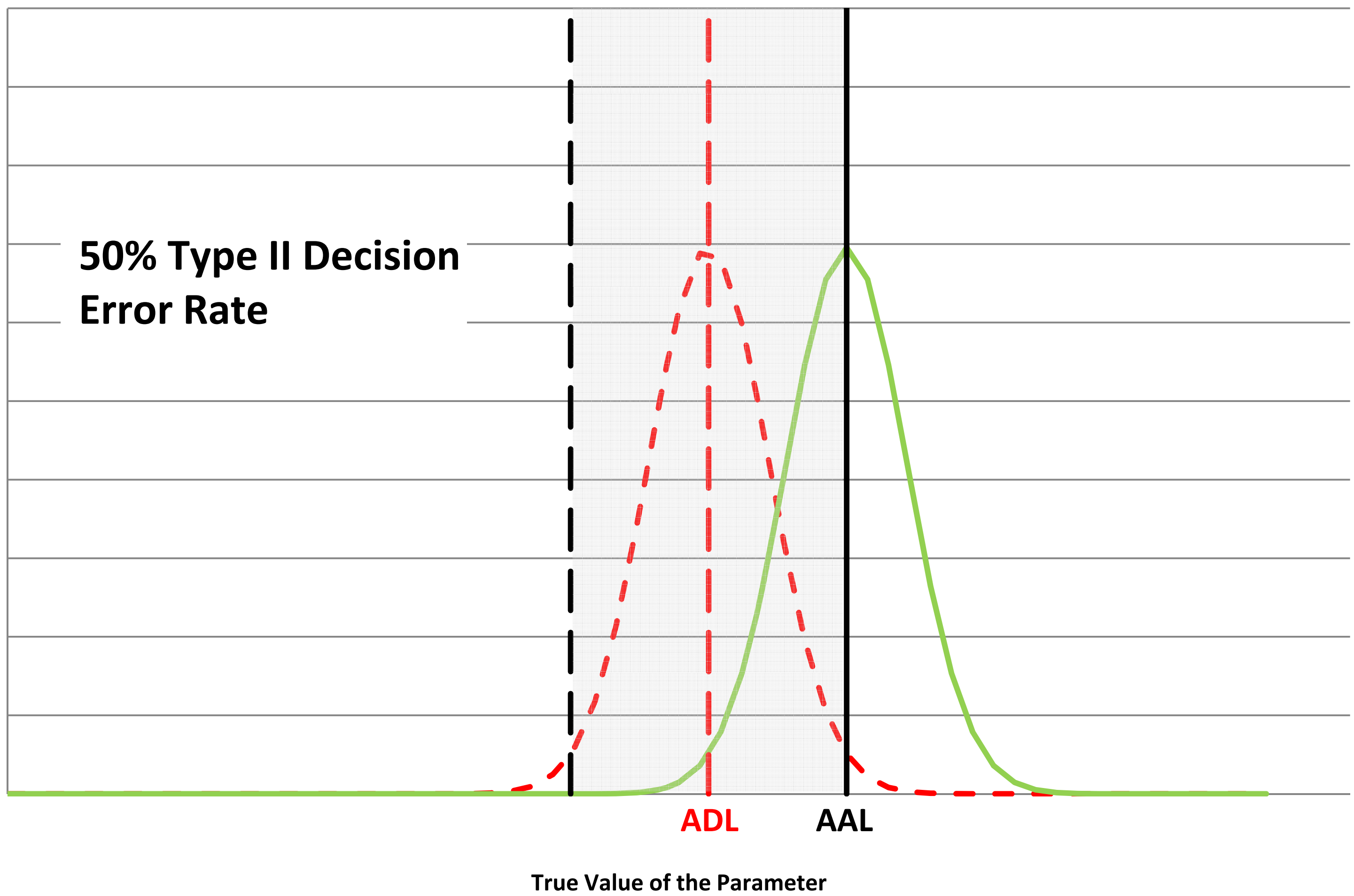
Decision Performance Goal Diagram



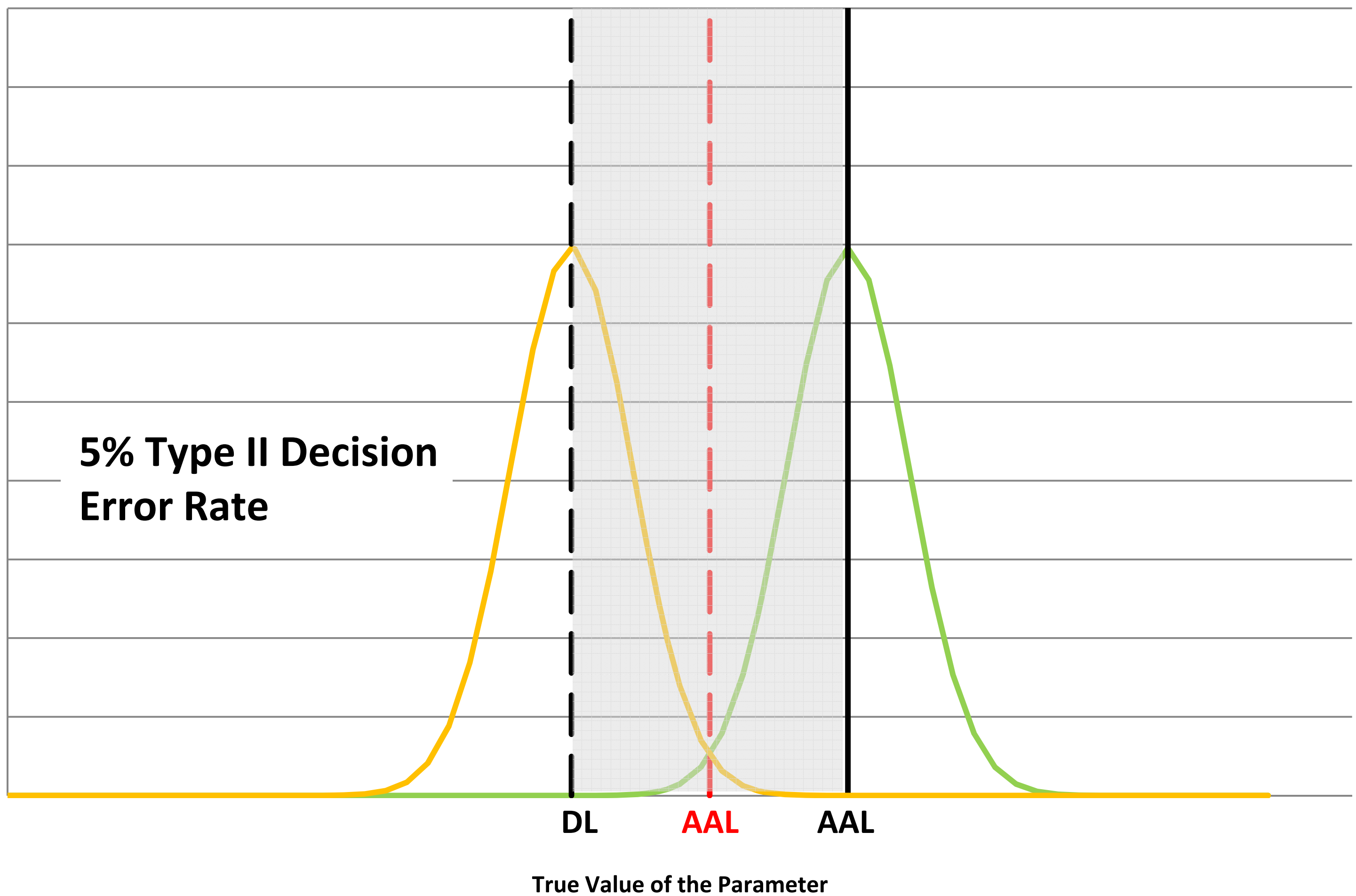
Probability of a Type I Decision Error



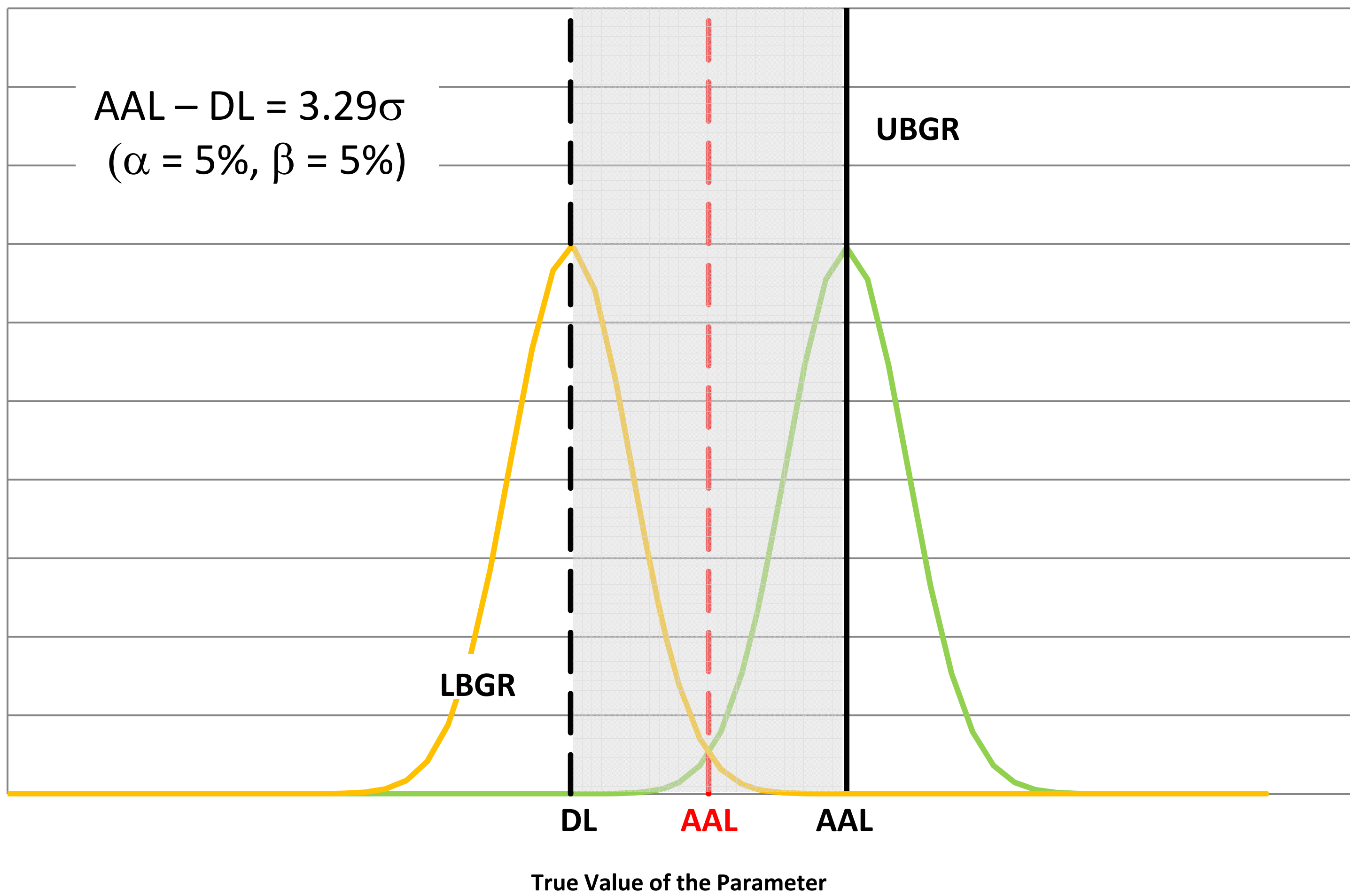
Probability of a Type II Decision Error



The Discrimination Limit

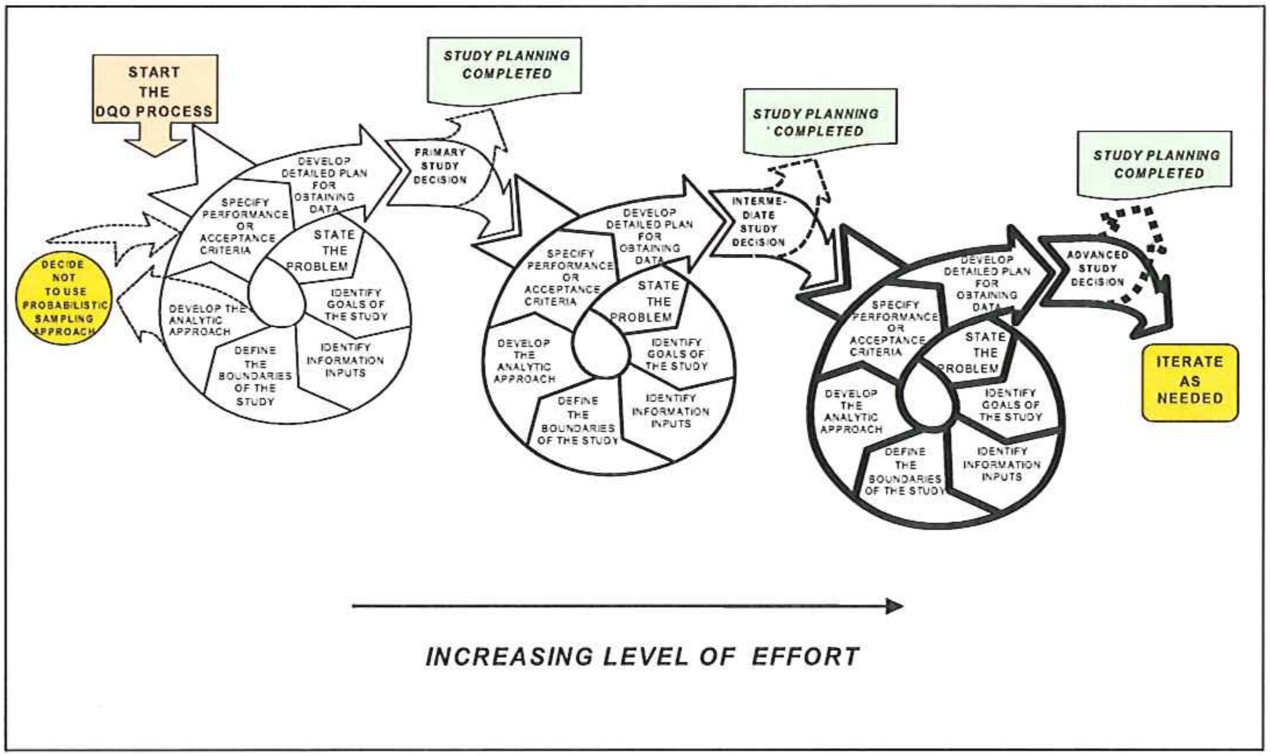


The Gray Region



The DQO Process - Continued

- Step Seven: Optimize the Design for Obtaining Data



Measurement Quality Objectives

MQOs – Measurement Quality Objectives

- What question are we trying to answer?
- Does a result exceed the AAL?
  - Uncertainty at the AAL is important
- Is a radionuclide present?
  - Detection limit is important
- Not practical to define both the uncertainty at the AAL and the required detection limit.

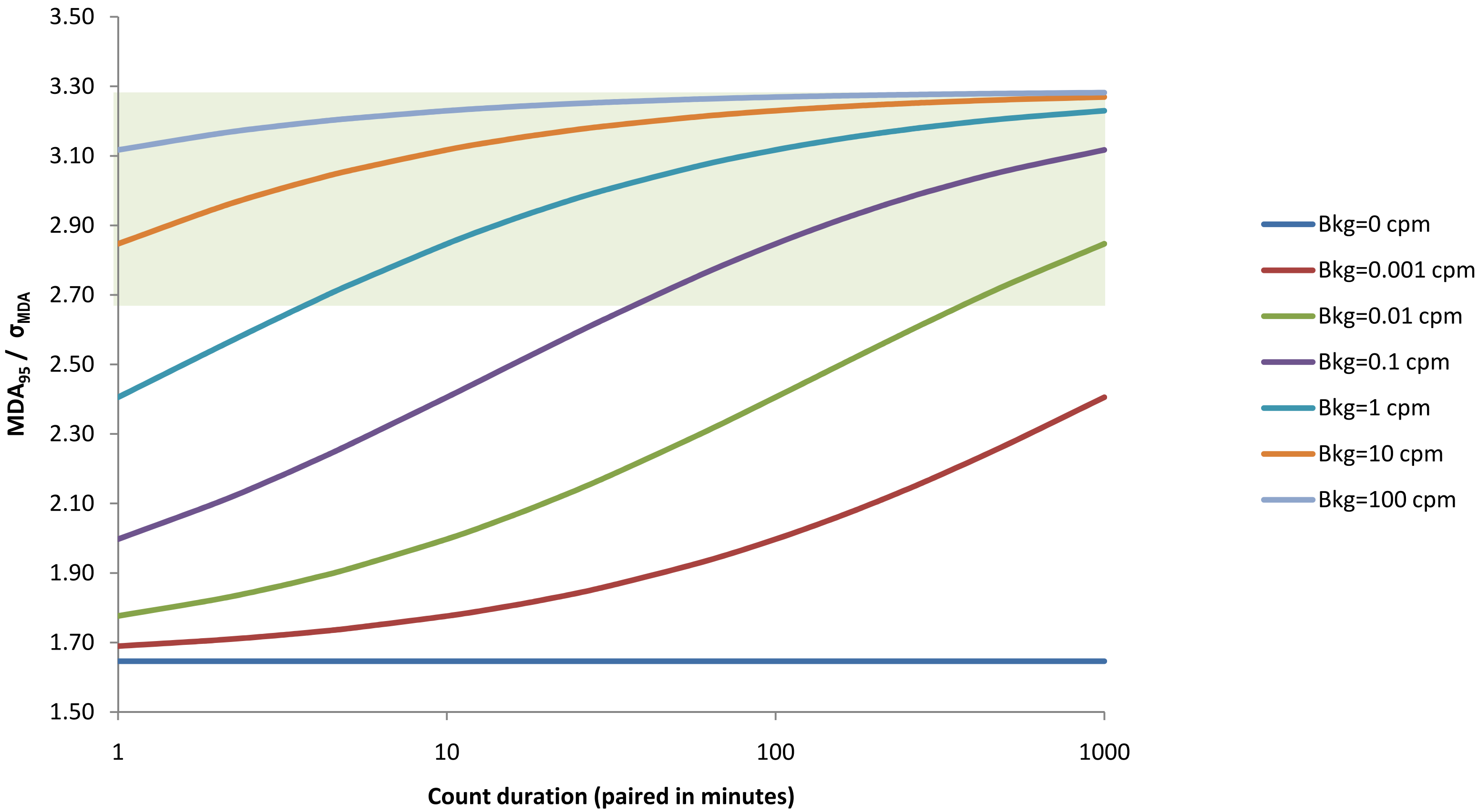
MQO – Uncertainty at the AAL

- Not common to count to an uncertainty at a specified activity.
- Difficult for data reviewers to ensure the uncertainty requirement is met.

MQO – Count to a Required MDA

- Not ideal for answering the question: Does a result exceed the AAL?
- Relationship between the uncertainty and the MDA allows us to use the MDA to force the uncertainty at the AAL.

Ratio of the MDA_{95} to the Standard of the Net Count Rate (Paired Counts)



(Courtesy of Robert Shannon, Quality Radiolanalytical Support)

Ratio of the MDA_{95} to the Standard of the Net Count Rate (Paired Counts)

Count Time (min.)	Background Count Rate, R_{BKG}						
	Bkg=0 cpm	Bkg=0.001 cpm	Bkg=0.01 cpm	Bkg=0.1 cpm	Bkg=1 cpm	Bkg=10 cpm	Bkg=100 cpm
1	1.65	1.69	1.78	2.00	2.41	2.85	3.12
2	1.65	1.71	1.82	2.10	2.55	2.95	3.16
3	1.65	1.72	1.86	2.17	2.63	3.00	3.18
4	1.65	1.73	1.89	2.22	2.68	3.03	3.20
5	1.65	1.74	1.91	2.27	2.73	3.06	3.21
10	1.65	1.78	2.00	2.41	2.85	3.12	3.23
15	1.65	1.80	2.06	2.49	2.91	3.15	3.24
20	1.65	1.82	2.10	2.55	2.95	3.16	3.25
30	1.65	1.86	2.17	2.63	3.00	3.18	3.25
60	1.65	1.93	2.30	2.76	3.07	3.21	3.26
100	1.65	2.00	2.41	2.85	3.12	3.23	3.27
150	1.65	2.06	2.49	2.91	3.15	3.24	3.27
200	1.65	2.10	2.55	2.95	3.16	3.25	3.27
240	1.65	2.13	2.58	2.97	3.17	3.25	3.28
300	1.65	2.17	2.63	3.00	3.18	3.25	3.28
500	1.65	2.27	2.73	3.06	3.21	3.26	3.28
1000	1.65	2.41	2.85	3.12	3.23	3.27	3.28

MQO – Required MDA

$$MDA_{95} = \left({}^{MDA_{95}}\!\!\diagup_{\sigma_{MDA}} \right) (\varphi_{MR}) (AAL)$$

- For most analyses: $\left({}^{MDA_{95}}\!\!\diagup_{\sigma_{MDA}} \right) \approx 3$
- If the required measurement uncertainty is 10% then:

$$\begin{aligned} MDA_{95} &= (3)(0.1)(AAL) \\ &= (0.3)(AAL) \end{aligned}$$

  – If the required measurement uncertainty is greater than 33% the MDA_{95} will be above the AAL.

Alphabet Soup

- PAGs – Protective Action Guides
- DCFs – Dose Conversion Factors
- DRLs – Derived Response Levels
- DWCs – Derived Water Concentrations
- DILs – Derived Ingestion Levels
- AALs – Analytical Action Levels
- ADLs – Analytical Decision Levels
- DQOs – Data Quality Objectives
- MQOs – Measurement Quality Objectives

Required MQOs

- Sample Type: Soil
- Requested Analysis: Gamma Spectroscopy

Radionuclide	Required MDA_{95}	Reporting Unit
Am-241	1.6E-01	µCi/Sample
Cs-137	5.13E+00	µCi/Sample

- Maximum Count Time: 1 hour
- Decay correct results to the sample collection date and time.
- Additional Instructions: Count the total sample, do not remove rocks, roots or leaves.

Additional Resources

1. Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, May 1992, EPA 400-R-92-001 (revised manual will be available for public comment soon)
2. FRMAC Assessment Manuals, Volumes 1-3, April 2003
3. Turbo FRMAC, Sandia National Laboratories
4. Radiological Laboratory Sample Analysis Guide for Incidents of National Significance – Radionuclides in Water, January 2008, EPA 402-R-07-007
5. Federal Guidance Report No. 13
6. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, February 2006, EPA/240/B-06/001
7. MARLAP, Volume 1, Appendix B, The Data Quality Objectives Process

Notes

- Add table (s) of typical MDAs
- Add DRLs from RAMS(?)
- MQOs for determining something is different than background (what radionuclides are there)
- Review MARLAP Appendix C – Measurement Quality Objectives for Method Uncertainty and Detection and Quantification Capability (Why does 10% uncertainty work?)
- Repeat definitions of acronyms more often